Forest Health Protection

Northeastern California Shared Service Area

2550 Riverside Drive, Susanville, CA 96130

Special Project Report

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Date: March 14, 2012
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To: District Ranger, Carson Ranger District, Toiyabe National Forest

Subject: Waterfall Fire – Mortality of Fire-Injured Trees (NE-SPR-12-02)

Thank you for allowing Forest Health Protection (FHP) to monitor fire-injured trees in the 2004 Waterfall Fire. As of 2009, we completed the five-year monitoring of 191 ponderosa and Jeffrey pine (combined as yellow pine). The Waterfall Fire provided an opportunity to obtain data to expand our current knowledge base and continue to improve the accuracy of predicting fire-injured tree mortality. In 2010, we used this data to help validate our current mortality models (Hood et al 2010) and improve our regional marking guidelines (Smith and Cluck 2011). Please refer to the attached 2005 administrative study plan for details on sampling procedures and study tree locations.

Monitoring fire-injured yellow pine in the Waterfall Fire revealed similar patterns of mortality to other fires in the Sierra Nevada and Cascade Mountain Ranges. First, the majority of the observed mortality occurred in trees that sustained high levels of crown kill and/or high levels of cambium kill (Tables 1 and 2). Crown injury is the most important variable in predicting tree mortality and yellow pines with high levels of crown kill have a high probability of mortality. For study trees, the average crown length kill was 63% for dead trees and 46% for live trees. Yellow pines with low to moderate levels of crown injury combined with high levels of cambium kill also have a higher probability of mortality. For study trees, the average cambium kill rating (number of dead tissue samples, from 0 to a maximum of 4) was 2.9 for dead trees and 1.5 for live trees. Four samples were collected from each tree regardless of the presence/absence of bole char. Second, most of the mortality (79%) occurred by the end of the second post-fire year (Table 3). This is consistent with other FHP monitoring that shows that approximately 80% of post-fire mortality occurs by year two. And finally, study trees that died in year 3 or later were slightly larger in diameter and generally had higher levels of cambium kill with lower levels of crown kill. This is also consistent with other FHP monitoring as these attributes tend to allow

trees to remain green until progressive decay of the fire-injured root collar and roots finally lead to reduced water transport to the crown and increased susceptibility to bark beetle attacks.

Data from this administrative study was used to help validate our current yellow pine mortality models. Our optimal yellow pine models based on fire-injured trees from the Cone and McNally Fires (Hood et al 2010) predicted the mortality and survival of the Waterfall trees with an overall accuracy of 82.6% and 75.8% respectively. The average diameter of the Waterfall study trees was very similar to the Cone Fire trees used in model development and may explain the greater accuracy over the McNally model. The Cone optimal yellow pine model had an 87.6% correctly predicted mortality rate and a 78.2% correctly predicted survival rate for the Waterfall study trees.

Mortality predictions from both the Cone and McNally models were recently combined to develop fire-injured tree marking guidelines for yellow pines in California (Smith and Cluck 2011). These guidelines provide land managers with a science based tool to meet post-fire management objectives. Based on the results of the Waterfall fire-injured tree monitoring, it appears that these guidelines are suitable for the eastside of the Sierra Nevada range within the boundaries of the Toiyabe National Forest. These guidelines and FHP assistance with implementation are available upon request by contacting our Region 4 FHP office in Ogden, UT.

In conclusion, FHP greatly appreciates the cooperation of District personnel in setting up and completing this study and looks forward to working with you again as opportunities arise. Please contact me if you have any questions.

/s/ Danny Cluck

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cc: Amanda Brinnand, Forester, Carson RD
Steve Munson, Group Leader/Entomologist, R4 FHP, Ogden Field Office
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Citations (both available from FHP upon request):

Hood, S.M., S.L. Smith, and D.R. Cluck. 2010. *Predicting mortality for five California conifers following wildfire.* Forest Ecology and Management. 260: 750-762.

Smith, S.L. and D.R. Cluck. 2011. *Marking guidelines for fire-injured trees in California*. US Forest Service, Forest Health Protection, Region 5, Susanville, CA. Report # RO-11-01. 13 p.

Summary of data for the 2004 Waterfall Fire

Waterfall study trees averaged 18.2" dbh (range 10.0" to 39.4" dbh). Most of the trees are presumed to be Jeffrey pine (*Pinus jeffreyi*) but species information beyond "yellow pine" was not collected.

Table 1. Number of trees by cambium damage rating (and % mortality) and mortality by year.

Cambium Damage Rating	# of Trees	2005 Mortality	2006 Mortality	2007 Mortality	2008 Mortality	2009 Mortality
0	29 (10%)	0	2	1	0	0
1	36 (33%)	2	8	2	0	0
2	36 (50%)	5	8	5	0	0
3	40 (70%)	2	22	3	1	0
4	50 (78%)	13	17	4	3	2

- Rating of 0-4 is based on a cambium sample taken in each of four equally spaced directions near ground level. A rating of 0 is equal to no fire damage for any sample and 4 is dead cambium at each sample location.

Table 2. Number of trees by percent remaining live crown length (and % mortality) and mortality by year.

Live Crown (%)	# of Trees	2005 Mortality	2006 Mortality	2007 Mortality	2008 Mortality	2009 Mortality
0<35	46 (89%)	10	27	3	1	0
>=35	145 (41%)	12	30	12	3	2

- Trees designated for harvest within the 2004 Waterfall Fire had less than 35% remaining live crown length.

Table 3. Total number of trees (and % mortality) and mortality by year (and % of total mortality).

Species	# of Trees	2005 Mortality	2006 Mortality	2007 Mortality	2008 Mortality	2009 Mortality
Ponderosa/Jeffrey (Yellow) Pine	191 (52%)	22 (22%)	57 (79%)	15 (94%)	4 (98%)	2 (100%)

Forest Health Protection
Pacific Southwest Region

ADMINISTRATIVE STUDY

SURVIVABILITY OF FIRE INJURED TREES
WATERFALL FIRE
CARSON RANGER DISTRICT, TOIYABE NATIONAL FOREST

This project addresses the primary objective of improving post-fire management decisions regarding the use and accuracy of salvage marking guidelines.

Specifically we will:

- 1) Evaluate the accuracy of the marking guidelines prescribed for fire-injured trees in the 2004 Waterfall Fire and 2) Supplement existing probability of mortality curves for ponderosa and Jeffrey pine (combined as yellow pine) three growing seasons after wildfire as a function of tree diameter, cambium kill and crown kill.

Background and Need

Prior to 2000, fire-salvage marking guidelines used throughout California were based on a paper by Willis Wagener (1961). There have been numerous other publications (Bevins 1980; Reinhardt & Ryan 1988; Ryan 2000; Ryan & Frandsen 1991, Lynch 1959, Petersen 1985) involving fire damage and tree mortality, however, Wagener's is the only work conducted in California. In 1995, following the Barkely Fire (burned in 1994, Lassen NF) and the Crystal Fire (burned in 1994, Tahoe NF), Forest Health Protection (FHP) staff located in Susanville, CA initiated studies to attempt to validate Wagener's marking criteria. Several FHP monitoring studies have followed providing the basis for the current marking guidelines (based on Hood et. al. 2005 draft).

The 2004 Waterfall Fire provided an opportunity to obtain data to expand our current knowledge base and continue to improve the accuracy of predicting fire injured tree mortality. We intend, through this project, to supplement our data base and develop probability of mortality curves that can be used to modify the current guidelines. Data collected and analyzed in this project will

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improve the accuracy of various fire injury and insect attack criteria used for predicting tree mortality.

Methods

Locate and tag 180 trees for inclusion in the study.

Individual trees were located within the 2004 Waterfall Fire. The selected trees were monumented by painting a number at breast height that corresponded with a metal numbered tag near ground level. Trees were double banded with yellow paint around the entire circumference to facilitate relocation. A stem map was created to illustrate tree locations within the study area. The selected trees will be protected for the duration of this study from management activities that could influence the results.

Table 1. Criteria for tree selection.

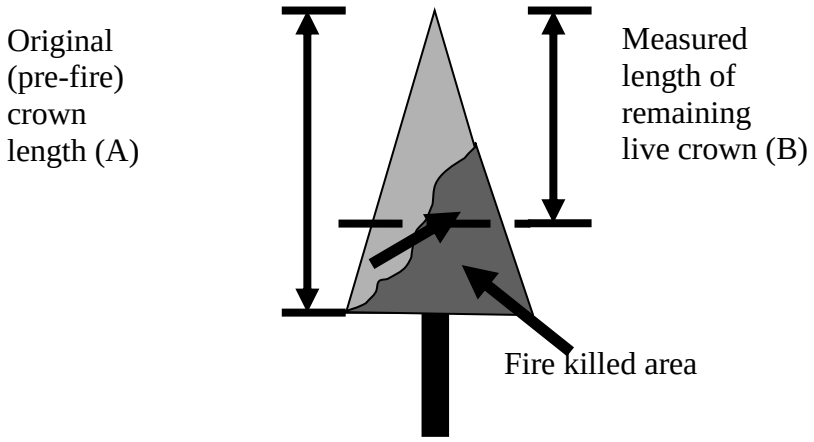
DBH classes	% Remaining Live Crown (as percentage of original pre-fire crown length)
10" – 20"	40-49 %
20" – 30"	30-39 %
	20-29 %

Individual tree information included species, dbh, tree height, and percent live crown length (pre-fire). Fire damage information collected for each tree included percent of crown length killed and a cambium kill rating. Any signs of insect activity such as frass, boring dust, or pitch tubes were noted. General site information was collected as appropriate. A summary of data collected is provided in Appendix A.

Determining Crown Injury

The amount of crown kill was determined by measuring the original (pre-fire) crown height (or length) and then measuring the height (or length) of remaining live crown to calculate the percent remaining live crown (Figure 1). Crown kill is the percent of original live crown minus the percent of remaining (post-fire) live crown.

Figure 1. Linear measurement of crown kill.



B/A*100 = Percent remaining live crown.

Determining Cambium Kill Rating

The cambium kill rating was determined by drilling into the cambium close to ground-line at four evenly spaced locations around the tree using a power drill with a 1" bit hole saw bit to see if the cambium is live (L) or dead (D). Live tissue feels moist, soft, and spongy. The color varies by species, but is generally a light, peachy shade. Dead cambium is typically hardened and has a darker appearance. Cambium may also be resin impregnated, due to high internal temperatures that cause the resin ducts in the tree to burst. Individual tree ratings were from 0-4, the total of all dead samples.

Determining Insect Attack

Insect activity including an estimate of percent bole circumference with frass or boring dust and estimate of the number of bark beetle pitch tubes will be noted for each tree. Trees that have detectable diseases, pathogens or large "cat faces" from previous fires will not be included in the study.

Monitoring

The study was implemented during the summer of 2005 and will continue for a minimum of five years. Individual trees will be monitored annually beginning in 2005. The need for revisits beyond that will be determined at that time. Trees that die during the duration of the study will continue to be followed through time, if possible, to document snag longevity.

Data Steward: FHP will initiate data management and be responsible for data collection.

Reports: FHP will write annual monitoring reports and distribute as appropriate.

Literature Cited

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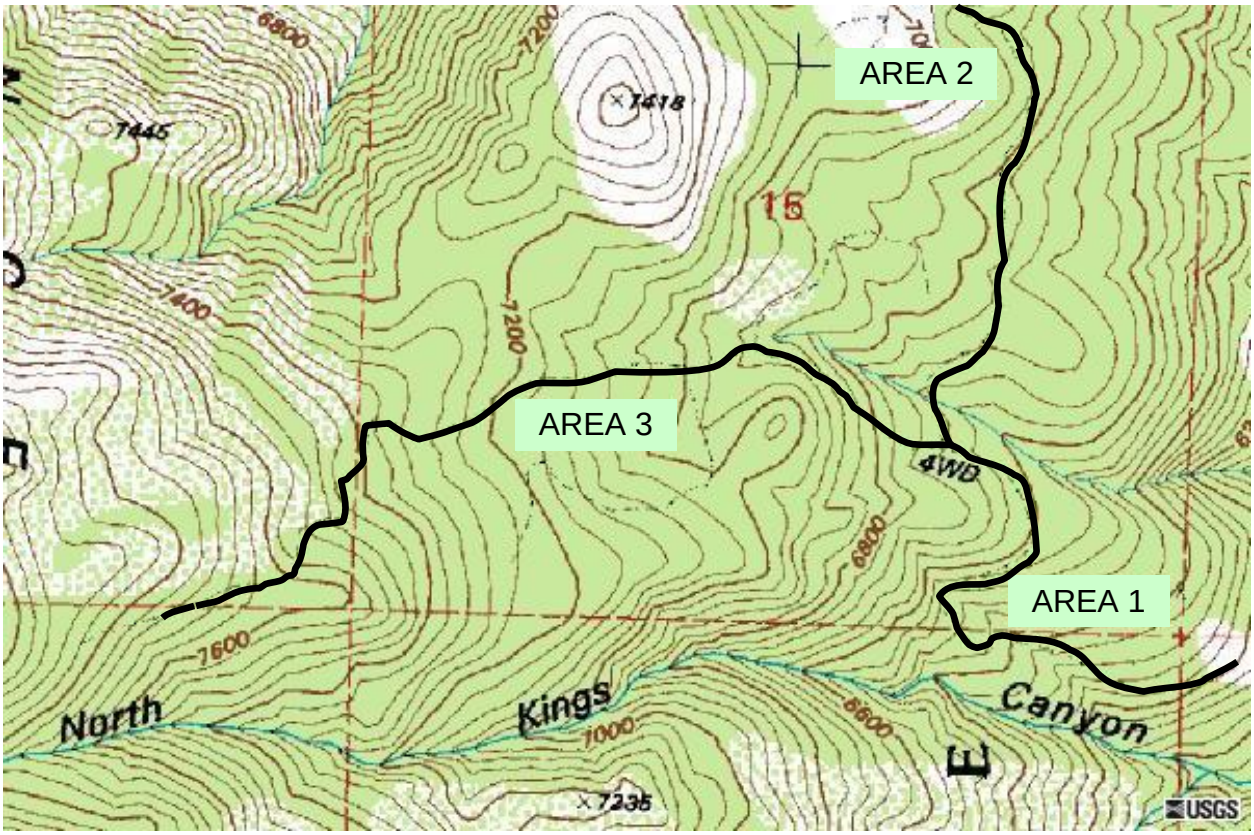
WATERFALL FIRE STUDY TREES

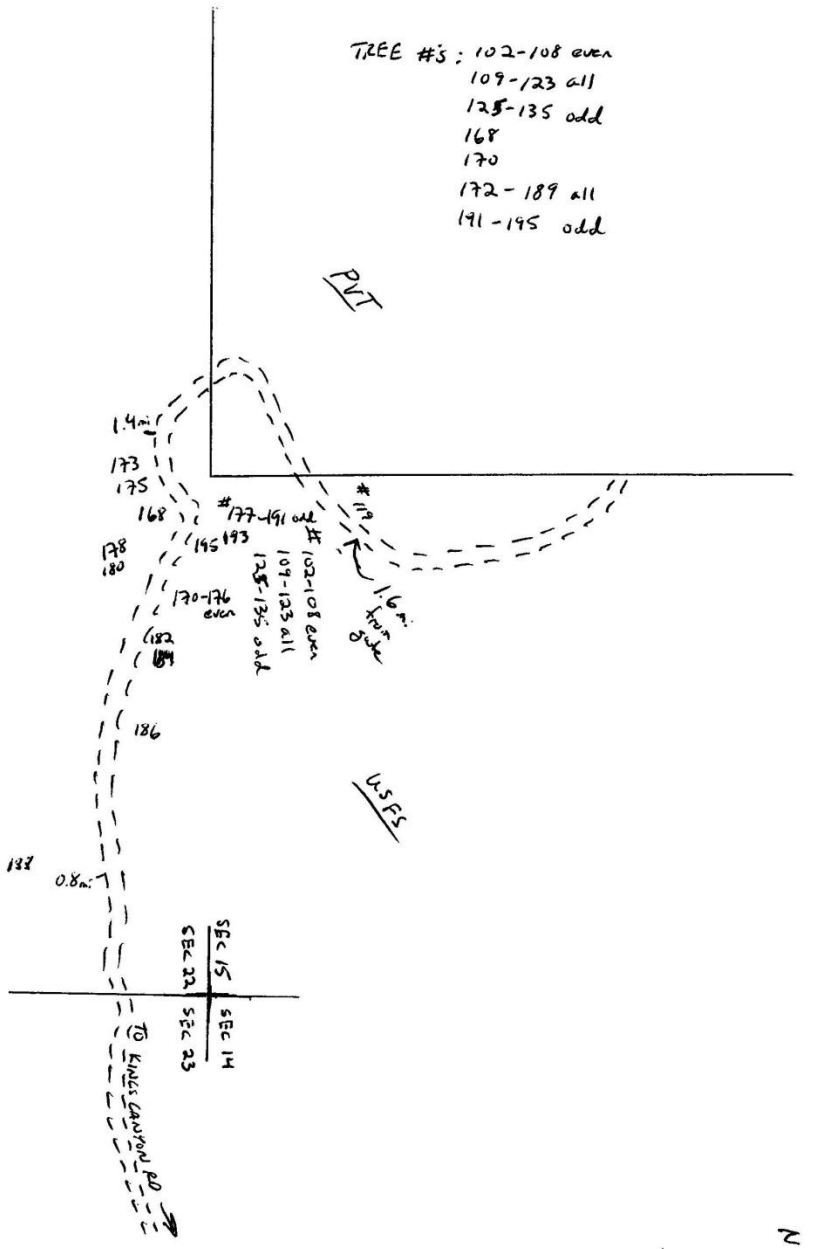
T15N, R19E, Sections 15,16,21,22



WATERFALL FIRE STUDY TREES

AREA 1

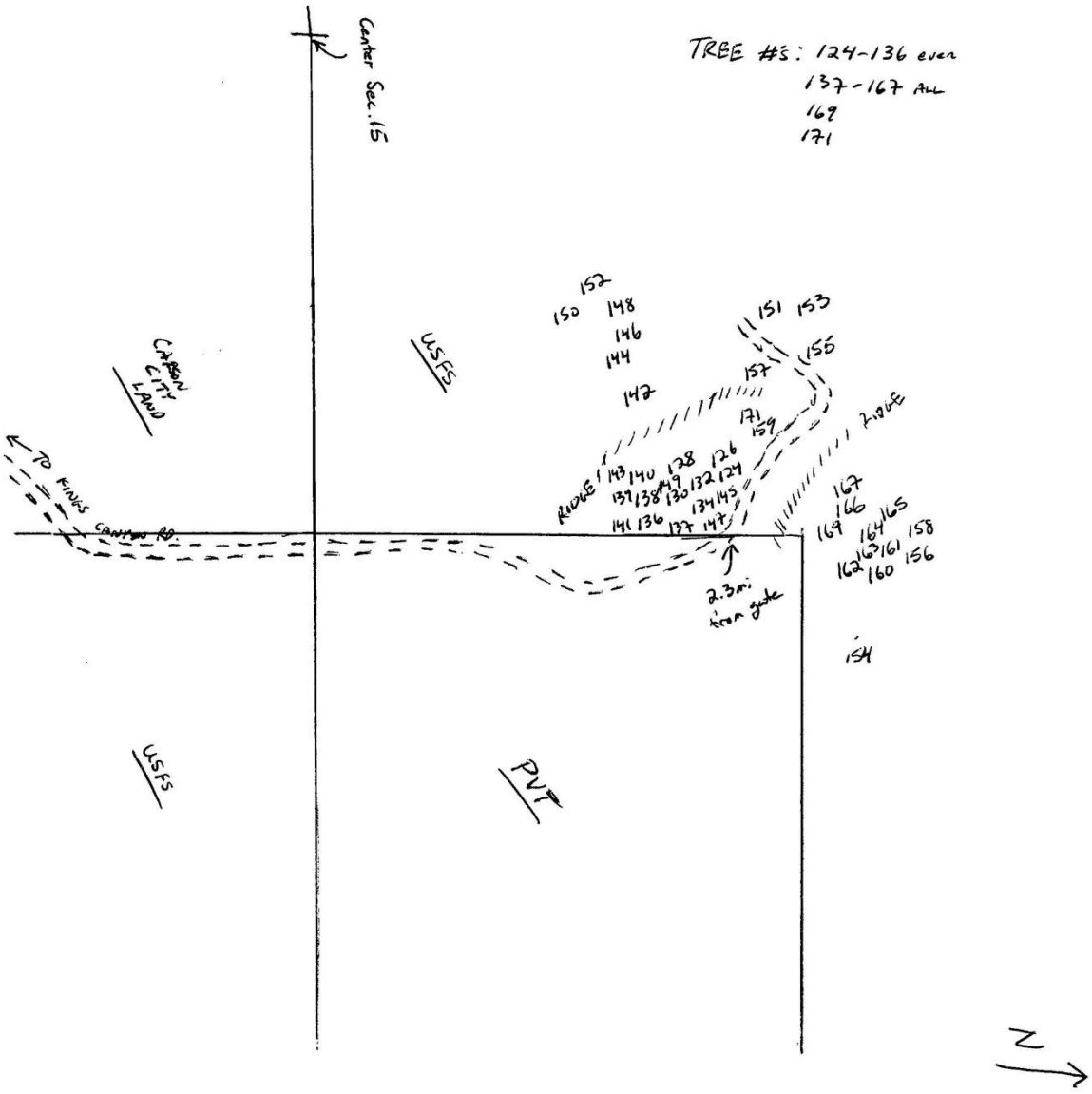
* General Locations

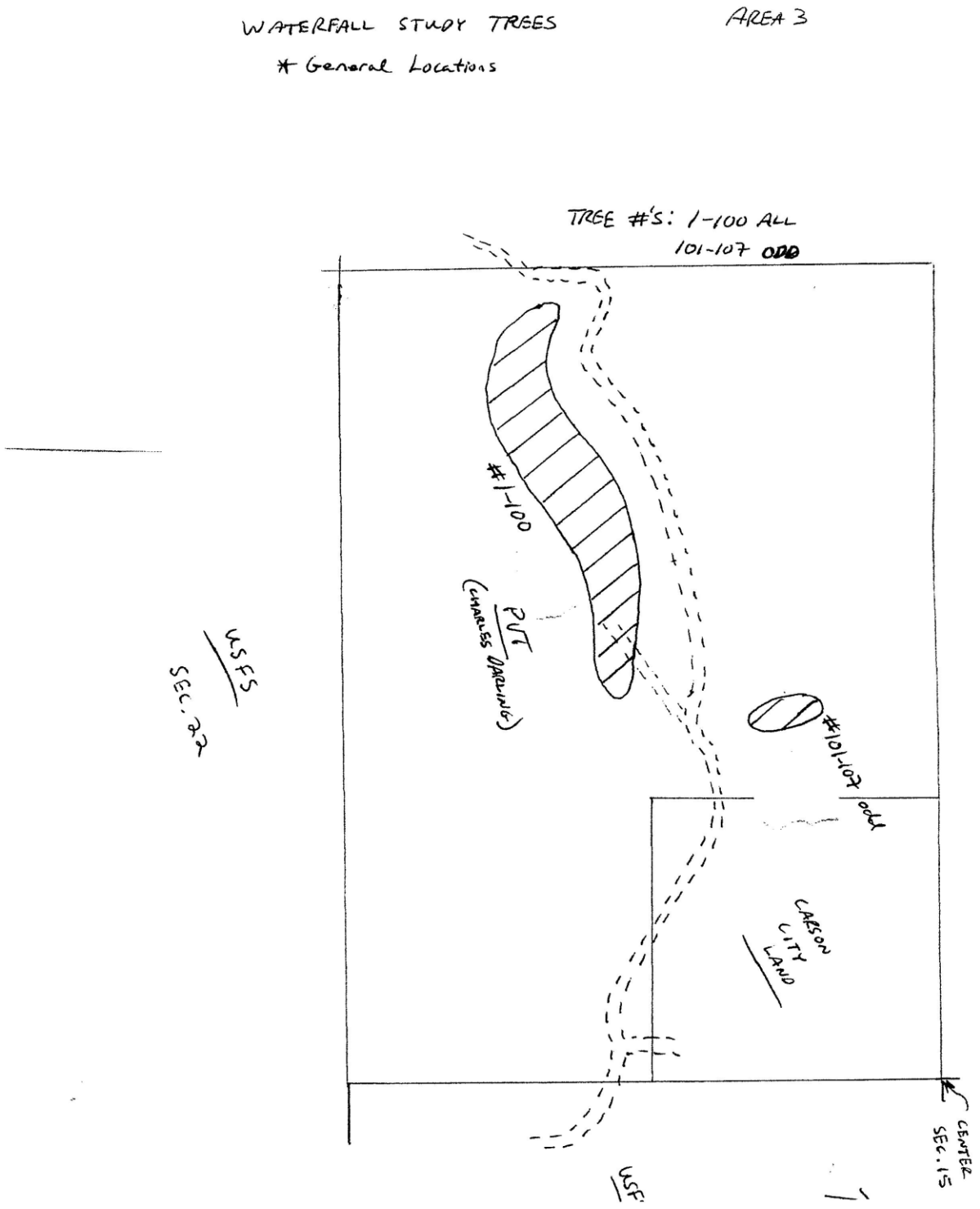


WATERFALL STUDY TREES

AREA 2

*General Locations





Permisson to complete this administrative study on private land was granted by the landowner, W.H. Long (the reference to Charles Darling on the map is incorrect).